DISRUPTIVE DISCHARGES OF ELECTRICITY THROUGH FLAMES.

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In a paper published by the Academy of Science of St. Louis[1] the author pointed out the essential difference in character between the effects of X-rays in the ionization of air and that produced in a column of air exposed to the positive terminal of an influence machine.

The action of X-rays is to dislodge negative corpuscles from some of the air molecules and load them upon others. Such a mass of air is said to have the property of conduction. Some of the molecules in it will accept negative corpuscles from those to whom they have delivered them or from the terminal of a negatively charged electrometer. Other molecules will deliver their overload of negative corpuscles to an electrometer terminal from which negative corpuscles have been drained, or to the molecules which they have robbed. If left to itself such a mass of air soon loses its property of conduction. The average corpuscular charge of a molecule in such a mass of air is the normal amount.

In a mass of air which forms the positive column due to the action of an influence machine the negative corpuscles have been drained, or are being drained into the positive or exhaust terminal. In air of ordinary pressure it is found that in air thus drained of negative corpuscles, a disruptive discharge diffuses into the drained region. The disruptive channel widens and apparently ceases to have a disruptive character within the region thus drained. In a few cases the disruptive channel has re-formed on the other side of such a cloud-like mass which had apparently drifted over the photographic plate and away from the positive terminal.

[1] *Trans.*, Nos. 1 and 4, Vol. XIX., and No. 1, Vol. XX.

An illustration of this action is shown in Fig. 1. A photographic plate had the heads of two pins resting upon the film. They formed the terminals in a gap in a discharge line from the negative terminal of an eight-plate influence machine to ground. Between this gap and the machine was another gap of about 1 mm., which was at the large knob of the machine.

In order to produce the effect shown in the figure, the machine was turned very slowly for several minutes. Small discharges occurred at the small gap. When there was danger of a spark between the pin-heads, the machine was stopped for twenty or thirty seconds and then continued. This resulted in draining the negative corpuscles from the air around the grounded pin-head. A progressive elongation of these drainage lines was examined in a series of plates in which this operation was continued for an increasing time interval, the plates being then developed.

In Fig. 1 after continuing the slow driving of the machine for about three minutes, its speed was then suddenly increased and a disruptive discharge passed over the photographic film between the pin-heads.

This plate is one of many hundreds that have shown this phenomenon of a diffused conduction in the region around the positive end of the disruptive channel. This channel began at the negative pin-head, in the midst of the negative glow. That region was not in a condition of conduction for the negative discharge, and has not been in any case observed. Fig. 1 is one of a few cases where the discharge wandered considerably from the line joining the pin-heads. In some cases the plate was in the positive line. In some cases the two pin-head terminals were directly connected to the positive terminals of the machine with minute gaps at the machine. In all cases the diffusion area was formed at the positive pin-head terminal. In all cases the appearance shown in Fig. 1 was observed. The appearance is that which might be caused by a volley of negative corpuscles discharged from the end of the disruptive channel, and aimed at the pin-head forming the positive, in this case the grounded, terminal. The pin-head shielded that portion of the film which was behind it and in line with this discharge from the fogging effect observable around it. The air-film which carried the discharge was in close contact with the film, as is shown by the character of the shadow. The lowest part of the rounded pin-head only was effective in this shielding of the film, as is shown in Fig. 1.

The interior of the disruptive channel is also a drainage or conduction channel. It is in a highly rarified condition, approaching that of a vacuum tube. The discharge which passes through it is in the nature of a cathode discharge. The air molecules which form the stepping stones for this conduction discharge are urged in the opposite direction from that in which the corpuscular discharge is

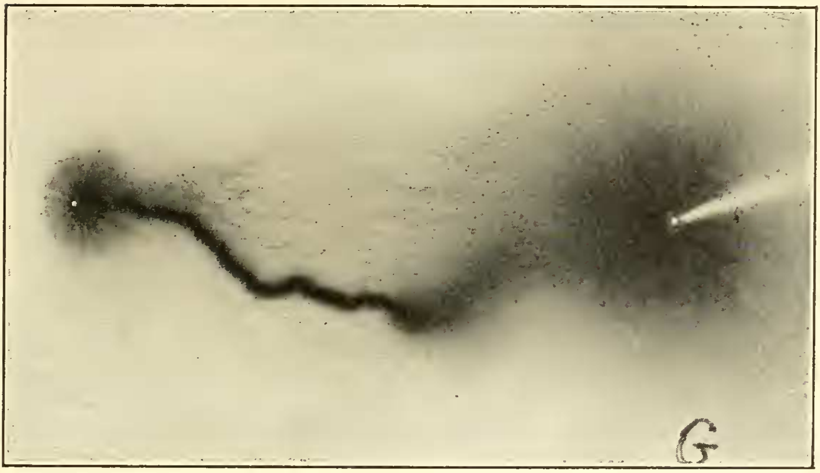

Fig. 1.

passing. This is incidental to the fact that the conductor is in gaseous form. These air molecules have in some cases produced effects at the negative terminal, similar to those shown in Fig. 1. They are, however, less marked in character. They are in the nature of "canal rays," as observed in a vacuum tube. A photographic plate showing such effects was reproduced in a former paper.[2] In a copper wire the transfer from atom to atom likewise occurs. There the atoms cannot yield, they are nearer together, and the phenomena of conduction are much more simple.

[2] *Trans. Acad. of Sci. of St. Louis*, Vol. XIX., No. 4, plate XXII., Fig. A.

An attempt was made to compare the conduction-properties of a drainage column of air like that shown in Fig. 1, with those of the flame of a blast lamp. Fig. 2 shows a camera photograph of disruptive discharges between a red-hot ball of iron hung on a wire suspension by means of which it was grounded, and the negative terminal of the influence machine. The ball was heated by a blast lamp, the air being fed from a tank at about two atmospheres pressure. A similar flame was placed between the hot ball and the nega-

Fig. 2.

tive terminal, so that the discharges passed through it. On account of the long exposure, the contrast between the flame and the individual sparks is not very distinct. Some of the sparks show a partial photographic reversal. The discharge lines are, however, all more or less clearly visible within the flame. Fig. 3 shows a single spark, made under the same conditions, although the flame was exposed for nearly half a minute before the spark passed. Fig. 4 shows a similar photograph in which the exposure to the flame was not over half of a second. There are two discharge lines visible, although only one discharge could be distinguished by the sound. The fainter discharge came from the red-hot ball, and crossed the track of the brighter spark, which came from a hook serving for suspension of the ball on a grounded wire. The track of the fainter spark is as sharply defined within the flame as that of the brighter one. In Figs. 3 and 4 the discharge was in the positive line. The hot ball was grounded.

FIG. 3.

It is evident from these results that the conduction of the gases within the flame of the lamp is very much less than is shown in the positive column near the anode terminal in Fig. 1. In that figure, the air within the disruptive channel is highly rarefied. This channel is a hole bored through the air. The discharge through this channel issued from the end and continued as "sheet lightning" across the drainage area surrounding the grounded anode. This drainage area is not in the rarefied condition which exists within the disruptive spark channel. This part of the discharge must be practically noiseless. The sound produced by the spark is caused by the collapse of the spark channel in a manner similar to that caused by the crack produced by the end of a whip-lash, which also cuts a hole in the air. When an electrical discharge occurs between clouds or between

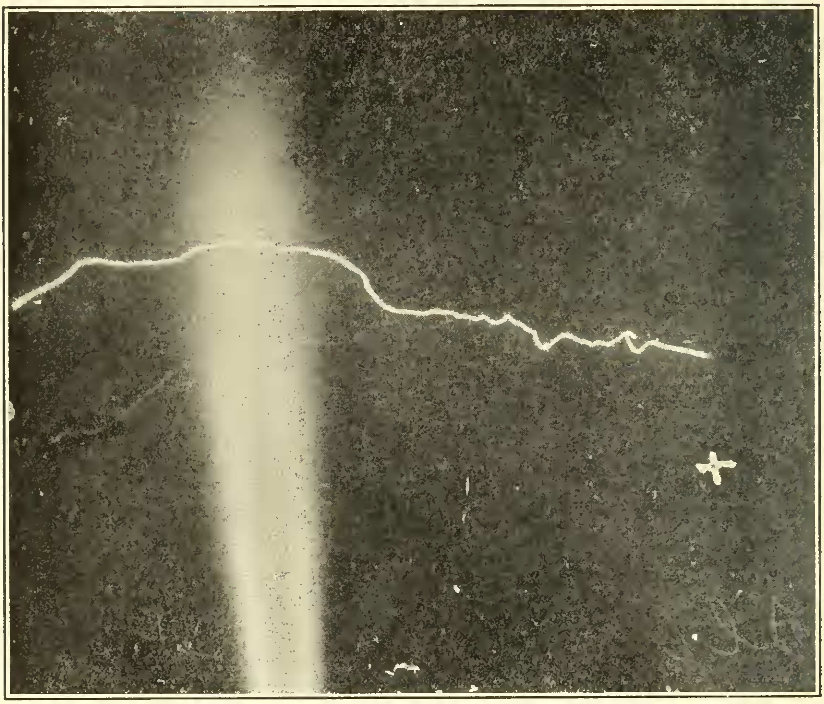

FIG. 4.

a region containing an excess and one having a deficiency of electrical corpuscles, the latter region must be in a condition like that surrounding the grounded anode in Fig. 1. The disruptive channel will diffuse into it. This region is one which is properly called a region of conduction.

The other end of the discharge channel must penetrate regions where the air is super-charged with corpuscles. It is not in the same sense a region of conduction. Here tributary discharge channels will form. These discharge channels branch out from the main channel and elongate in a direction opposite to that in which the corpuscular stream is flowing. This end of the discharge is called forked lightning. Probably in most cases the ends of the discharge are hidden by clouds.

Fig. 1 is a reproduction of the original plate. Figs. 2, 3 and 4 are reproductions of photographic reversals of the originals.